UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

SEP 6 _ 2018

Ron Dean
Branch Chief
Intergovernmental Consultation and Conservation
National Marine Fisheries Service
1845 Wasp Blvd., Bldg 176, Room 2542
Honolulu, HI 96818

Dear Mr. Dean:

The purpose of this letter is to request the National Marine Fisheries Service (NMFS) written concurrence, under Section 7 of the Endangered Species Act (ESA) and 50 CFR Section 402.13(a), with the U.S. Environmental Protection Agency (EPA) Region 9's determination on the possible effects of approval under Section 303(c)(3) of the Clean Water Act (CWA) of water quality standards (WQS) by the Commonwealth of the Northern Mariana Islands (CNMI) Bureau of Environmental and Coastal Quality (BECQ).

BECQ revised their cadmium water quality standards applicable to all saltwater in CNMI. Their water quality standards were public noticed on May 25, 2018 and a public hearing was held on July 13, 2018. The water quality standards were adopted by CNMI on August 28, 2018 and transmitted to EPA in a letter dated September 5, 2018.

BECQ previously adopted saltwater water quality standards for tributyltin, nonylphenol, carbaryl and diazinon on June 11, 2014. EPA approved the tributyltin, nonylphenol, carbaryl and diazinon water quality standards on May 1, 2015. EPA had previously initiated consultation on these four parameters but ESA consultation had not been concluded. As a result, the analysis of these parameters has been included in the enclosed Biological Evaluation (BE).

The BE documents the EPA's analysis of the effects of approving the water quality standards action on listed species under NMFS jurisdiction. The EPA has determined that approval of the water quality standards may affect, but is not likely to adversely affect threatened or endangered species. This conclusion is based on the effects on listed species which are expected to be discountable or insignificant.

The EPA is requesting NMFS's concurrence with our "may affect, but not likely to adversely affect" determination, in accordance with the procedures outlined in the Memorandum of Agreement Between the Environmental Protection Agency, Fish and Wildlife Service, and

National Marine Fisheries Service regarding Enhanced Coordination Under the Clean Water Act and Endangered Species Act, dated February 22, 2001. If you have any questions, please contact Nicole Tachiki of my staff at (415) 972-3161 or tachiki.nicole@epa.gov.

Sincerely,

Janet Hashimoto

Janet Hashimoto, Chief
Water Quality Assessment Section

Enclosure

cc: Randy McIntosh, NOAA Fisheries

Biological Evaluation of the Commonwealth of the Northern Mariana's Water Quality Standards for Cadmium, Carbaryl, Diazinon, Nonylphenol, and Tributyltin

Prepared by:

U.S. Environmental Protection Agency
Region 9
75 Hawthorne St.
San Francisco, CA 94105

2018

Table of Contents

I. Introduction

This Biological Evaluation (BE) analyzes the U.S. Environmental Protection Agency (EPA) actions on the Commonwealth of the Northern Mariana Islands (CNMI) Bureau of Environmental and Coastal Quality (BECQ) water quality standards. BECQ adopted the water quality standards on August 28, 2018. EPA is submitting this BE as part of a consultation under the Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.). The scope of the consultation includes EPA's action on BECQ's adoption of a saltwater cadmium standard.

The scope of this BE also includes EPA's previous approvals of saltwater standards for diazinon, carbaryl, nonylphenol, and tributyltin standards adopted by CNMI on June 11, 2014 and approved by EPA on May 1, 2015. EPA had previously initiated consultation with NMFS on these four parameters, but ESA consultation had not been concluded.

This BE addresses the potential impacts of cadmium, diazinon, carbaryl, nonylphenol and tributyltin to listed species under the jurisdiction of the National Marine Fisheries Service (NMFS) and in the area affected by the federal action, pursuant to Section 7 of the ESA and 50 CFR Section 402.13(a).

II. Description of Action

BECQ submitted a package of adopted water quality standards to protect aquatic life from acute and chronic exposure to cadmium, ammonia, and selenium for all Commonwealth or state waters. However only cadmium applies to marine waters. The parameters from the 2015 action include adopted acute and chronic standards for carbaryl, diazinon, nonylphenol, and tributyltin standards which all apply to saltwater environments.

<u>Cadmium.</u> CNMI BECQ adopted EPA's 2016 national recommended aquatic life ambient water quality criteria for cadmium which reflects the latest scientific information. EPA published the original national recommended cadmium aquatic life criteria in 1980. The 2016 criteria are an update to the 1980 criteria using the best available science with data for 75 new species and 49 new genera.

Carbaryl. CNMI BECQ adopted EPA's 2012 national recommended aquatic life ambient water quality criteria for carbaryl in 2015. The acute saltwater criterion was based on toxicity data from 12 species (11 genera).

Diazinon. CNMI BECQ adopted EPA's 2006 national recommended aquatic life ambient water quality criteria for diazinon in 2015. The acute criterion was based on toxicity data from 7 invertebrates and 2 fish species.

Nonylphenol. CNMI BECQ adopted EPA's 2005 national recommended aquatic life ambient water quality criteria for nonylphenol in 2015. The EPA acute criteria is based on toxicity data from 8 invertebrate and 3 fish species.

Tributyltin. CMMI adopted EPA's 2004 national recommended aquatic life water quality criteria for tributyltin in 2015. The saltwater acute criterion is 0.42 µg/L and the saltwater chronic criteria is 0.0074 µg/l. The acute criterion was based on toxicity data from 8 invertebrates and 3 fish species. The chronic criterion was initially based on chronic toxicity data species, but the criterion was lowered to address a large body of evidence of tributyltin associated with imposex (i.e. females developing male sex organs) in gastropods.

Table 1 Summary of saltwater criteria that are the subject of this biological evaluation.

Pollutant	Saltwater CMC[1] (µg/L)	Saltwater CCC[2] (µg/L)	CNMI Adoption	EPA Approval
Cadmium	33	7.9	2018	Pending
Carbaryl	1.6	N/A	2014	2015
Diazinon	1.6	0.82	2014	2015
Nonylphenol	7	1.7	2014	2015
Tributyltin	0.42	0.0074	2014	2015

[1] CMC: Criterion Maximum Concentration. The duration and frequency of the acute criteria is a one-hour average concentration not to be exceeded more than once every three years.
[2] CCC: Criterion Continuous Concentration. The duration and frequency is a four-day average concentration not to be exceeded more than once every three years for chronic criterion.

III. Description of the Area Affected

The Commonwealth of Northern Marianas is in the Marianas archipelago. The total land area is 183.5 square mile. The population is 53,883 based on the 2010 Census. Most of the population lives on Saipan. The main industries are tourism and garment manufacturing.

The CNMI water quality standards apply to all waters of the Commonwealth. They are mostly used to establish the appropriate level of treatment for permits. The authority to write permits has not been delegated to CNMI, so all the permits are written by EPA Region 9. There are five National Pollutant Discharge Elimination System (NPDES) permits for Saipan: three wastewater treatment plants (WWTPs) and two stormwater permits.

The Agingan WWTP treats the domestic wastewater from approximately 18,400 people. The capacity of the plant is 3 million gallons per day (MGD). The WWTP also receives about 0.2 MGD of wastewater from commercial and/or industrial operations, such as automobile repair shops, gasoline stations, and power generators. The outfall extends ~650 feet offshore into Tinian Channel and discharges at a depth of 94 feet.

The Sadog Tasi WWTP treats the domestic wastewater for approximately 20,000 people. The plant capacity is 2.9 MGD. The total average daily wastewater flow from all industrial sources in the service area is less than 0.2 MGD. The plant discharges to Saipan Lagoon through an outfall located 1,200 feet offshore, at a depth of about 49 feet.

The new Managaha Island WWTF serves a daily tourist population up to 1,050 and receives domestic sewage with a design flow of 0.005 MGD which drains the treated wastewater to a nearby leach field, located approximately 150 feet inward of the north shoreline of Managaha Island in Saipan Lagoon.

The CNMI Municipal Separate Storm Sewer System (MS4) permit is intended to address stormwater impacts from the urbanized portions of Saipan, roughly the lower 2/3 of the island. There is also an industrial stormwater permit regulating storm-related discharges from the Mobil Oil Bulk storage facility which allows episodic discharges of stormwater to Tanapag Harbor.

The saltwater aquatic life criteria apply to marine and coastal waters including lagoons and harbors. This biological evaluation is focused on threatened and endangered species that may be affected by changes in the water quality standard.

IV. Listed Species

Table 2. Species list confirmed by the NMFS on April 11, 2018

Species	Scientific Name	ESA Status	Federal Register Reference
Green Sea Turtle (Central West Pacific Distinct Population Segment (DPS))	*Chelonia mydas*	Endangered	81 FR 20057
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	43 FR 32800
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	35 FR 8491
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Threatened	43 FR 32800
Loggerhead Sea Turtle (North Pacific DPS)	*Caretta caretta*	Endangered	76 FR 58868
Blue Whale	*Balaenoptera musculus*	Endangered	35 FR 18319
Fin Whale	*Balaenoptera physalus*	Endangered	35 FR 18319
Sei Whale	*Balaenoptera borealis*	Endangered	35 FR 18319
Sperm Whale	*Physeter macrocephalus*	Endangered	35 FR 18319
Humpback whale. (Western North Pacific DPS)	*Megaptera novaeangliae*	Endangered	81 FR 62259
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened	83 FR 4153

Scalloped Hammerhead Shark. (Indo-West Pacific DPS)	*Sphyrna lewini*	Threatened	79 FR 38213
Giant Manta Ray	*Manta birostris*	Threatened	83 FR 2916
Corals	*Acropora globiceps*	Threatened	79 FR 38213
	Seriatopora aculeata	Threatened	79 FR 53851
	Acropora retusa	Threatened	79 FR 53851
Species	**Scientific Name**	**ESA Status**	**Federal Register Reference**
clam, giant (7 candidate species)	*Hippopus hippopus* *Hippopus porcellanus* *Tridacna costata* *Tridacna derasa* *Tridacna gigas* *Tridacna squamosa* *Tridacna tevoroa*	ongoing petition	82 FR 28946

SEA TURTLES

The green turtle is globally distributed and generally found in tropical and subtropical waters along continental coasts and islands between 30° North and 30° South. Adult green turtles feed primarily on seagrasses and algae. Adult and juvenile green turtles are generally found nearshore as well as in bays and lagoons, on reefs, and especially in areas with seagrass beds. Adults migrate from foraging areas to nesting beaches and may travel hundreds or thousands of kilometers each way.

Hawksbills can be found in tropical and sub-tropical regions throughout the world. This species can be found nesting and foraging in other Pacific US territories but research on the population status and trends in these areas is on-going. Hawksbills feed around coral reefs and rock outcroppings and primarily consume sponges.

Loggerheads have large heads with powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conches. In the eastern Pacific, loggerheads have been reported as far north as Alaska, and as far south as Chile. The west coast of Mexico, including the Baja Peninsula, provides critically important developmental habitats for juvenile loggerheads. The only known nesting areas for loggerheads in the North Pacific are found in southern Japan.

Western Pacific leatherbacks nest in the Indo-Pacific and migrate back to feeding areas off the Pacific coast of North America. Leatherbacks feed on a diet of soft-bodied, pelagic (open ocean) prey, such as jellyfish and salps. Western Pacific leatherbacks swim from tropical nesting beaches in the western Pacific to foraging grounds in the neritic eastern North Pacific. The trans-Pacific journey requires10-12 months to complete.

The Olive Ridley sea turtle is pelagic and migrates great distances between feeding and breeding grounds. They breed annually and have an annual migration from pelagic foraging to coastal breeding and nesting grounds. The Olive Ridley sea turtle has been known to inhabit coastal areas, including bays and estuaries.

WHALES

Blue whales are found worldwide, from sub-polar to sub-tropical latitudes. Poleward movements in spring allow the whales to take advantage of high zooplankton production in summer. Blue whales are largely pelagic but they can be found in coastal waters.

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics. They occur year-round in a wide range of latitudes and longitudes. They eat herring, capelin, squid, euphausids and copepod.

Sei whales occur in subtropical, temperate, and subpolar waters around the world. They feed on plankton, small schooling fish, and cephalopods. They are typically observed in deeper waters far from the coastline

Humpback whales live in all major oceans from the equator to sub-polar latitudes. Humpback whales travel great distances during their seasonal migration. In the summer, humpbacks are found in high latitude feeding grounds. In the winter, they migrate to calving grounds in subtropical or tropical waters. During the summer months, humpbacks spend most of their time feeding and building up fat stores (blubber) that they will live off during the winter. Humpbacks filter feed on tiny crustaceans (mostly krill), plankton, and small fish.

Sperm whales are the largest of the toothed whales. Sperm whales are found throughout the world's oceans in deep waters between about 60° N and 60° S latitudes. Sperm whales tend to inhabit areas with a water depth of 1,968 feet (600 m) or more, and are uncommon in waters less than 984 feet (300 m) deep. Their principle prey are large squid, demersal and mesopelagic sharks, skates, and fishes.

SHARKS AND RAYS

The oceanic whitetip shark is found throughout the world in tropical and sub-tropical waters. It is a pelagic species, generally remaining offshore in the open ocean, on the outer continental shelf, or around oceanic islands in water depths greater than 600 feet. They live from the surface of the water to at least 498 feet deep. Oceanic whitetip sharks have a strong preference for the surface mixed layer in warm waters above 20°C, and are therefore a surface-dwelling shark. They feed on squid and octopus and many types of fish. It has also been known to feed on stingrays, sea turtles and birds.

The scalloped hammerhead shark is a pelagic species that can also be found in ocean waters and occurs over continental and insular shelves and adjacent to deeper water. Scalloped hammerhead sharks are found worldwide residing in coastal warm temperate and tropical seas in the Atlantic, Pacific, and Indian Oceans between 46°N and 36°S to depths of 1000 meters. It has been observed close inshore and even entering estuarine habitats. It feeds primarily on fish such as sardines, mackerel, and herring, and occasionally on cephalopods such as squid and octopus.

The giant manta ray is found worldwide in tropical, subtropical, and temperate bodies of water and is commonly found offshore, in oceanic waters, and near productive coastlines. The giant manta ray is a migratory species, and seasonal visitor along productive coastlines with regular upwelling, in oceanic island groups. They are filter feeders and eat large quantities of zooplankton.

CORALS

Acropora globiceps occurs in Guam, CNMI, American Samoa, and the Pacific Remote Island Areas. *A. globiceps* occurs on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 meters.

Acropora retusa is likely to be distributed in the Commonwealth of the Northern Mariana Islands (CNMI). *A. retusa* occurs in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, and its depth range is 0 to 5 meters.

NMFS considers *Seriatopora aculeata* to occur in Guam and CNMI. *S. aculeata* occurs in a broad range of habitats on the reef slope and back-reef, including but not limited to upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons in a depth range of 3 to 40 meters.

CLAMS

The giant clam lives in flat coral sand or broken coral and can be found at depths of as much as 20 m. Giant clams are the largest living marine bivalves and typically inhabit tropical coral reefs in coastal regions throughout the Indo-Pacific.

Giant clams are members of the Subfamily *Tridacnidae*, which consists of two genera: *Hippopus* and *Tridacna*. Modern giant clams are distributed along shallow shorelines and on reefs in the Indo-West Pacific in the area confined by 30° E and 120° W and between 36° N and 30°. The giant clams mainly occur within the tropical Indo-Pacific region. The clam's mantle tissue is a habitat for the symbiotic single-celled dinoflagellate algae (zooxanthellae) from which the adult clams get most of their nutrition. By day, the clam opens its shell and extends its mantle tissue so that the algae receive the sunlight they need to photosynthesize. Giant clams are planktotrophic but they can acquire nutrition required for maintenance from their symbiotic algae, *Symbodinium. Tridacna gigas*, comfortably satisfies all apparent carbon requirements from the combined sources of filter-feeding and prototrophy (Klumpp and Lucas 1994). *T. derasa* can function as a complete autotroph in its natural habitat (down to 20 m), whereas *T. tevoroa* only achieves this in the shallower parts of its distribution (10 to 20 m).

V. Anticipated Effects

Water quality standards establish the concentrations of contaminants that are deemed to be protective of aquatic life. They can be used in evaluating protectiveness of water quality monitoring results. They can also be used to establish effluent limits for discharge permits to water. States can also use water quality standards to condition Federal actions through 401 certifications. The effects determinations are grouped and summarized below with the supporting information.

Cadmium

Cadmium is a naturally occurring metal found in mineral deposits and is distributed widely at low concentrations in the environment. Cadmium's primary industrial uses are for the manufacture of batteries, pigments, plastic stabilizers, metal coatings, alloys and electronics. Recently, cadmium has been used in manufacturing nanoparticles for use in solar cells and color displays. None of the monitoring data for any of the permitted dischargers on CNMI reveal any effluent levels of cadmium. Acute exposure causes increased mortality in aquatic organisms. Chronic exposure leads to adverse effects on growth, reproduction, immune and endocrine systems, development and behavior in aquatic organisms. Cadmium is widely distributed in the environment and can be introduced to marine organisms by ingestion of food, seawater and maternal transfer.

In equatorial ocean waters, cadmium concentrations are around 9 ng/l in the upper water column and around 100 ng/l below 150 meters depth. Denton et al 2006 reported that cadmium concentrations in sediments in Tanapag Lagoon are low, suggesting that there is not a major source of cadmium to the lagoon.

Whales. Cadmium accumulates in tissues of marine mammals worldwide (Chen et al, 2017, and references therein). All the whale species of concern (Table 2) are migratory and are generally found offshore. As whales do not generally drink saltwater, the primary pathway for the accumulation of toxins is through the food web. Squid species, deep water fish and jellyfish are a significant source of cadmium in marine mammals (Honda et al., 1983; Bustamante et al., 1998). Cadmium concentrations in whales and other large predators generally increase with size (age). Cadmium is concentrated in the liver and kidneys of whales. Cadmium binds to metallothionein in the liver and is subsequently transported to the kidneys.

Sharks. Sharks are generally getting cadmium from food. Cadmium is also known to accumulate in the liver of sharks (Vas, 1991; Turoczy et al., 2000, Endo et al., 2008, Barrera-García et al., 2013). Evans and Weigarten (1989) showed in the lab that cadmium concentrations on the order of 10 to 100 ug/l could cause vasoconstriction of vascular endothelium of dogfish sharks. Similarly, Wang et al., 1999 showed that cadmium levels on the order of 10 to 100 ug/l also affected the vasodilation pressure and the shape of the electrocardiogram in dogfish hearts isolated in the lab.

Sea Turtles. Ingestion is thought to be the biggest route (Storelli et al.,2005, Ikonomopoulou et al., 2011). Green turtles are largely herbivorous. Leatherback feed almost exclusively on jellyfish and loggerhead turtles are carnivorous. Leatherback turtles accumulated higher levels of cadmium as jellyfish are high in cadmium (Caurant et al.,1999). Cadmium is eliminated quickly from turtle blood and stored in the liver where it binds with metallothionein and is eventually stored in the kidney (Guirlet and Das, 2012). Concentrations in Green sea turtle eggs near Hong Kong are low (Lam et al., 2006). Maternal transfer of cadmium to turtle eggs is low (Paez-Osúna et al.,2010, Ikonomopoulou et al., 2011, Sakai et al., 2000, Storelli et al.,2005).

Clams. The EPA cadmium criteria document provided toxicity for 14 bivalve species. The LC_{50}s ranged from 23,200 ug/l for the dogwhelk (*Nucella lapillus*) to 60 ug/l for the horse clam (*Tresus capax*). Cadmium is highly accumulated in molluscs (Honda, 1990). Duquesne and Coll 1995 found significant reduction in the zooxanthellae of *Tridacna crocea* exposed to cadmium concentrations of 200 ug/l over a 10-day period.

Corals. Nacci et al., 1986 established a cadmium EC50 for *Acropora punctulata* at 38,000 ug/l. Reichelt-Brushette and Harrison (1999) observed that fertilization success of gametes from the *Goniastrea aspera* and *Oxypora lacera* were not affected by cadmium concentrations of 200 µg/l and 1,000 ug/l, respectively. The gametes from the reef coral *O. lacera* showed no decrease in fertilization success up to 1000 ug/l of cadmium. Reichelt-Brushette and Harrison (2005) found that *Acropora tenuis* from the Great Barrier reef had fertilization reduced at cadmium concentrations above 5,000 ug/l (NOEC = 2,000 ug/l). Mitchelmore et al., 2007 documented mortality in *Pocillopora damicornis* corals exposed to 50 ug/l.

Summary. EPA's approval of the CNMI's cadmium water quality standard is not likely to affect whales and sharks as they are mostly pelagic organisms and not likely to spend significant time in the near shore environment. EPAs' research has not found any thresholds in the Ecotox database or in the scientific literature for the listed species or surrogates that are less than either the acute (33 ug/l) or chronic (7.9 ug/l) cadmium standards. EPA finds that the cadmium standards are not likely to adversely affect any of the threatened or endangered whales, sharks, turtles, clams or corals identified by NMFS.

Carbaryl

Carbaryl is a member of the N-methyl carbamate class of pesticides, which share a common mechanism of toxicity by affecting the nervous system in animals. Carbaryl also affects plant development and is used to thin fruit in orchards. Carbaryl (Sevin®) is a pesticide used to control insects, slugs and snails and to thin fruit in orchards. It can enter water bodies through runoff and potentially pose risks to aquatic life. Carbaryl is the second most frequently found insecticide in water, with detections in approximately half of monitored urban streams. After contact with or ingestion by aquatic organisms, the toxic mode of action of carbaryl is inhibition of the enzyme acetylcholinesterase (AChE) at synaptic junctions in the nervous system. AChE breaks down the neurotransmitter acetylcholine. Inhibition of AChE results in the accumulation of acetylcholine in the nerve synapses which leads to continual firing of nerve pulses throughout the nervous system. This buildup results in uncontrolled movement, paralysis, convulsions, tetany, and possible death. Without proper nerve function, the respiratory, circulatory and other vital body systems will fail, ultimately causing death of the organism. The acetylcholinesterase inhibition effects of carbaryl are reversible with removal of exposure of the stressor chemical.

Whales. There is no information on carbaryl and mammals in the EPA criteria document or the Ecotox database. Most carbaryl mammal studies are done on mice and rats. A summary of the effects of carbaryl on mammals was provided by Gunasekara et al., 2008 and references therein. "AChE inhibition also causes the toxicity of carbaryl to mammals, although, in contrast to insects, the mammalian effect involves synapses in the peripheral nervous system, including those in glandular structures and at neuromuscular junctions, in addition to those in the central nervous system. Because of the hydrolytic instability of the carbamate-AChE bond, recovery of mammals from acute effects is expected when exposures are low....The metabolism of carbaryl has been extensively studied in mammals. In general, it does not accumulate in mammalian tissue and is rapidly metabolized to less-toxic substances, particularly 1-naphthol, which are eliminated in urine and feces (Tomlin 2000). The main pathways include oxidation, via hydroxylation and epoxidation, and hydrolysis (Carpenter et al., 1961, Dorough and Casida 1964)."

No acceptable data on the bioaccumulation of carbaryl in freshwater or estuarine/marine waters are available; however, because of its low octanol/water partition coefficient (229), carbaryl is not expected to bioconcentrate to a significant extent (U.S. EPA 2010). There is little threat of carbaryl accumulation through consumption of prey species.

<u>Sharks</u>. The EPA carbaryl criteria document identified toxicity data on Sheepshead minnows (*Cyprinodon variegatus*) and Threespine stickleback (*Gastersosteus aculeatus*). The LC_{50}s for *C. variegatus* were 2,200 and 2,600 ug/l (Suprenant 1985 and Lintott, 1992). The LC_{50} for *G. aculeatus* was 3,990 ug/l (Katz, 1981). As discussed above carbaryl is not expected to bioconcentrate to a significant extent.

<u>Turtles</u>. Aguirre et al., 1994 analyzed the shell and tissue of Green Sea turtle hatchlings from the Hawaiian Islands for a number of chemical contaminants; carbaryl was not detected at concentrations above the detection limit of 100 ug/l. de Solla and Martin (2011) evaluated the uptake of carbaryl on snapping turtles (*Chelydra serpentina*) exposed to soil with carbaryl at the agronomic rate. There was no uptake in the eggs after 8 days of exposure. At ten times the agronomic rate there was uptake after 1 day.

Hopkins et al., 2005 found that carbaryl concentrations of 5,000 ug/l affected the swimming performance of neonate black swamp snakes (*Seminatrix pygaea*) and diamondback water snakes (*Nerodia rhombifer*). Most individuals recovered from the effects of carbaryl on swimming performance within 96 hours. As discussed above, carbaryl is not expected to bioconcentrate to a significant extent.

<u>Clams</u>. The 2016 carbaryl criteria document evaluated LC_{50} for a number of bivalves (mussels, oysters and clams). Stewart et al., 1967 established an LC_{50} for *Mytilus edulis* larvae of 2,300 ug/l. Liu and Lee 1975 published LC_{50}s for embryo/larvae of *M edulis* ranging from 1,210 to 1,800 ug/l. The LC_{50} of *Crassostrea virginica* larvae was reported as 2,700 to 3,000 ug/l (Suprenant et al., 1985, Davis and Hidu 1969). Similarly, Stewart et al., 1967 reported LC_{50} for *Crassostrea gigas* larvae as 2200 ug/l/. The LC_{50} for *C Virginica* juveniles was 2000 ug/l (Hansen 1980, Mayer 1987. LC_{50}s for the larvae of *Mercenaria mercenaria* was 3820 ug/l (Davis and Hindu, 1969). The LC50 for *Clinocardium nutalli* was 3,850. The LC_{50} for *Macoma nasuta* was 17,000 ug/l (Armstrong and Millemann, 1974).

Mora, 1999 established IC_{50}s based on inhibition of acetylcholinesterase after 24-hour exposure to carbaryl for *Mytilus galloprovincialis* (89 ug/l) and *Corbicula fluminea* (190 ug/l). Kopecka-Pilarczyk 2010 exposed *Mytilus trossulus* to a carbaryl concentration of 100 ug/l and found the greatest inhibition of acetylcholinesterase at 12 hours but reported that the effects of carbaryl disappeared after 48 hours.

<u>Coral</u>. Acevedo 1991 saw no effect on the planulae larvae of *Pocillopora damicornis* exposed to 10,000 ug/l carbaryl for 24 hours. Markey et al., 2007 found that carbaryl concentrations of 30 ug/l had no effect on the fertilization rate of *Acropora millepora* but 3 ug/l (LOEC) carbaryl could reduce metamorphosis of 7- and 8-day old larvae

Summary. EPA's approval of the CNMI's carbaryl water quality standard is not likely to affect whales and sharks as they are mostly pelagic organisms and not likely to spend significant time in the near shore environment. EPAs' research has not found any thresholds for the listed species or surrogates in the Ecotox database or in the scientific literature that are less than either the acute criteria of 1.6 ug/l. EPA finds that the carbaryl standards are not likely to adversely affect any of the threatened or endangered species identified by NMFS.

Diazinon

Diazinon is a pesticide traditionally used throughout the U.S. to control insects in agricultural areas, households and urban settings. Diazinon is mobile and moderately persistent in the environment. Diazinon is frequently found in wastewater treatment plant effluent and storm water runoff in urban and agricultural areas. Diazinon is known to be toxic to aquatic life, particularly invertebrates.

After December 31, 2004, it became unlawful to sell diazinon for outdoor, non-agricultural uses in the United States (that is, all residential uses of the insecticide diazinon have been cancelled). However, it is lawful to use diazinon for non-residential or agricultural uses that are consistent with product labeling and precautions approved by EPA under the Federal Insecticide, Fungicide and Rodenticide Act. There is no current use of diazinon on CNMI and is not imported to CNMI (Watts, 2015; Personal Communication with Zabrina Shai, BECQ Pesticide Inspector Aug 21, 2018).

<u>Whales</u>. There is no information on marine mammals in the EPA criteria document or the Ecotox database. Most papers on mammals and diazinon are for mice and rats. The mammalian LD_{50} is 1139 mg/kg (EFSA, 2006b, as reported in Crane et al., 2016). Given bioconcentration factors (BCFs) for a marine fish (sheepshead minnows, *C variegatus*) ranging from 147 and 213 (Goodman et al., 1979) we can develop a first order approximation of carbaryl concentration in prey species at water column concentrations equal to the chronic diazinon criteria (0.82 ug/l). Multiplying the BCF of 213 by the acute criteria of 0.82 ug/l, we estimate that marine prey would have a tissue concentration of 0.175 mg/kg, which is about 10,000 times lower than the mammalian LD_{50}.

<u>Sharks</u>. The EPA diazinon criteria document has toxicity data on two marine fish. The sheepshead minnow (*Cyprinodon variegatus*) and the inland silverside (*Menidea berrylinna*) had LC_{50}s for 1400 ug/l and 1,170 ug/l, respectively. One paper was found in the scientific literature demonstrating potential effects of diazinon on sharks. Hedayati and Tarkhani, 2014 found concentrations of diazinon at 500 ug/l caused changes in a number of blood parameters (such as red blood cell count; white blood cell count, hematocrit) in iridescent shark (*Pangasius hypophthalmus).*

Direct effects to sharks from diazinon are not expected due to dilution with marine waters. Diazinon is readily metabolized and does not accumulate in aquatic organisms, dietary exposure for shark species is of very low concern. Indirect effects (*i.e.*, reductions in prey), are not likely as the area around CNMI represents only a small fraction of the diet of the listed shark species.

<u>Turtles</u>. There is no information on turtles in the EPA criteria document or the Ecotox database. One report from the open literature suggested that diazinon was not present at detectable levels (10 ug/l) in the shell and tissue of Green Sea turtle hatchlings from the Hawaiian Islands (Aguirre et al 1994). The Ecotox database contained at least 14 papers on diazinon and birds. Most were based on incidental consuming of crystals by birds, or studies where diazinon was force fed (gavage). Lacking lethal dose information on turtles and reptiles, we use birds as surrogate species. The mallard duck has an oral dose LD_{50} of 1.44 mg/kg ((EFSA, 2006b, as reported in Crane et al., 2016) and can be used as a surrogate to assess the effect of trophic uptake by sea turtles. Assuming the BCF of 213 for the sheepshead minnow (*C. variegatus*) and assuming the acute diazinon criterion value of 0.82 ug/l we calculate a diazinon prey value of less than 0.175 mg/kg, an order of magnitude lower than the LD_{50} for the mallard. Using this as a first order approximation, we conclude that sea turtles are not likely to get much diazinon from its prey species.

<u>Clams</u>. Hemming and Waller (2004) developed diazinon 96-hr LC_{50}s for the Asiatic clam (*Corbicula fluminea*) and hooked mussel (*Ischadium recurvum*) and 354 μg/l and 4,067 μg/l, respectively. Choi et al., 2011 found a clear dose-response relationship between inhibited cholinesterase in adductor muscle of Manila clams and diazinon; the EC_{50} was 3010 ug/l.

<u>Coral</u>. There is no information in the EPA criteria document or in the Ecotox database on diazinon and cnidarians or zooxanthellae.

Summary. EPA's approval of the CNMI's diazinon water quality standard is not likely to affect whales and sharks as they are mostly pelagic organisms and not likely to spend significant time in the near shore environment. EPAs' research has not found any thresholds for the listed species or their surrogates in the Ecotox database or in the scientific literature that are less than either the acute criteria of 0.82 ug/l. In addition, diazinon is not used nor is it imported to CNMI. EPA finds that the diazinon standards are not likely to adversely affect any of the threatened or endangered species identified by NMFS.

Nonylphenol

Nonylphenols are alkylphenols that consist of a phenol group attached to a 9-carbon chain. They are used in manufacturing antioxidants, lubricating oil additives, laundry and dish detergents, emulsifiers, and solubilizers. These compounds are also precursors to the commercially important non-ionic surfactants alkylphenol ethoxylates and nonylphenol ethoxylates, which are used in detergents, paints, pesticides, personal care products, and plastics. Nonylphenols are likely to be introduced to the marine environment through wastewater and potentially through plastics in the ocean. Nonylphenol has attracted attention due to its prevalence in the environment and its potential role as an endocrine disruptor.

Nonylphenol concentrations in seawater are generally low. Kawahata et al., 2004 reported a maximum concentration of 0.17 ug/l nonylphenol at various sites in Okinawa and Ishigaki

Islands, Japan. Similarly, Kung et al., 2018 reported maximum concentrations of nonylphenol and nonylphenol ethoxylate 0.077 and 0.236 ug/l, respectively, in the coastal waters of southern Taiwan. Higher concentrations can be found in sediments (Kawahata et al 2004). Limited data are available for the effects of 4-nonylphenol on marine life in the Ecotox database or the scientific literature.

Whales. There is no information on the effect of nonylphenol and whales. Studies on rats have been done. Aso et al., 2000 demonstrated in estrus in adult female rats exposed orally to a dose of 150 mg/kg/d for 28 days. Moon et al., 2007 treated pregnant female rats in the late stage of gestation and found that female pups had increased uterus weight and advanced development of mammary tissue at 100 mg/kg/d.

The log K_{OW} of nonylphenol ranges from 3.80 to 4.77, this suggests that moderate bioaccumulation in aquatic organisms may be expected. However, reported laboratory bioconcentration factors (BCFs) and field-derived bioaccumulation factors (BAFs) do not support the expected accumulations in tissues, indicating that some nonylphenol is metabolized. Hecht et al., 2004 reported nonylphenol BCFs for the three marine amphipod species, *Eohaustorius estuarium, Grandidierella japonica* and *Corophidum salmonis*, of 154, 185, and 46 to 133, respectively. Assuming these crustaceans act as a reasonable surrogate for zooplankton, we can approximate the concentration of nonylphenol in the prey if the water column concentration was equal to the chronic nonylphenol concentration (1.7 ug/l). Multiplying 1.7 ug/l x 185, we would expect the prey to be 0.315 mg/kg which is much lower than the doses described above. We conclude that marine mammals are not likely to accumulate nonylphenol through the foodweb.

Sharks. Ward and Boeri 1990 found reduced growth and morphology in Sheepshead Minnow at 240 ug/l nonyphenol. Similarly, Martin-Skilton et al. 2006 found reduced growth and development in Atlantic Cod and Turbot with a NOECs of 29 ug/l nonylphenol. Pickford et al., 2003 evaluated the estrogenic effects of nonylphenol in fathead minnow (*Pimephales promelas*) through water exposure and oral exposure. Pickford et al. concluded that uptake of estrogenic activity was more likely through the gill and skin than through ingestion.

Turtles. While sea turtles are immersed in seawater, contaminants like 4-nonylphenol do not readily pass through their shell and skin into the body. Unlike gilled species, sea turtle exposures are not continuous because they do not drink continuously. Indirect exposures can occur through ingestion of food that has accumulated pollutants. In the Mediterranean Sea, Guerranti et al., 2014 reported that levels of p-nonylphenol in the green sea turtle and the loggerhead sea turtle were only slightly higher than the limits of detection. They noted that this may be the first report of nonylphenols in sea turtles in the scientific literature.

The Ecotox database does not include data on reptiles exposed to 4-nonylphenol, so studies from the open literature were used in this assessment. The induction of vitellogenin, impairment of spermatogenesis, and gonad abnormalities were reported in the Italian wall lizard exposed to drinking water dosed at 500,000 ug/l nonylphenol (Verderame et al., 2010; Verderame and Limatola 2015).

Cheng et al. 2017 demonstrated that the fertilization rates in Japanese quail were significantly reduced at concentrations as low as 0.1 ug/l. Survival rates were reduced with long term (4- to 14- day) exposure to nonylphenol at 1 ug/l. NMFS cited Cheng et al., 2017 Biological Opinion on Environmental Protection Agency's Approval of Florida's Proposed Water Quality Criteria for 4-Nonyphenol and determined that the nonylphenol standard does not adversely affect sea turtles.

Clams. Granno et al., 1989 found that the fertilization and early developmental success of *Mytilus edulis* were not affected at the highest concentration tested at 200 ug/l nonylphenol. Nice et al., 2000 observed a delay in development of D-shaped larvae at concentrations as low as 1 ug/l. Ricciardi et al., 2008 saw increases in vitellogenin in both male and female mussels (*Mytilus galloprovincialis*) at concentrations greater than 50 ug/l nonylphenol.

For the clam *Tapes philipinarum,* exposed over 7 days at 100 ug/l nonylphenol, there was a decrease in clearance rate and scope for growth (Matozzo et al., 2003). Mattozo and Marin, 2005 found increased vitellogenin in the Clam *T. philipinarum* over 7 days at concentrations as low as 100 ug/l. Marin et al., 2008 found toxicity in the cockle *Cerastoderma glaucoma* at concentrations of 300 ug/l. Increases in vitellogenin were observed in concentrations as low as 12.5 ug/l.

Liu et al., 2011 found a 12 h EC_{50} for trochophore of abalone (*Haliotis versicolor*) at 1016 ug/l and 96 hr EC_{50} for metamorphosis at 23 ug/l. Liu developed EC_5 for trochophore and metamorphosis at 319 ug/l and 1.4 ug/l, respectively.

Corals. Only one paper was found showing effects of nonylphenol on corals. Shafir et al., 2014 demonstrated that long-term exposure to nonylphenol ethoxylate caused mortality to two coral species (*Stylophora pistillata* and *Pocillopora damicornis*). They calculated an LC_{50} of 2160 ug/l. Using a freshwater cnidarian (*Hydra attenuate*), an LC_{10} value for embryos of 21 ug/l and an LC_{10} of 67 ug/l were calculated (Pachura et al. 2005, Pachura-Bouchet et al. 2006).

Summary. EPA's approval of the CNMI's nonylphenol water quality standard is not likely to affect whales and sharks as they are mostly pelagic organisms and not likely to spend significant time in the near shore environment. EPA finds that most species thresholds for the listed species or their surrogates in the Ecotox database or in the scientific literature are greater than either the acute (7 ug/l) or chronic (1.7 ug/l) nonylphenol standards. EPA finds that the nonylphenol standards are not likely to adversely affect any of the threatened or endangered species identified by NMFS.

Tributyltins

Tributyltin (TBT) is a class of organotin compounds which contain the (C4H9)3Sn group and were used in anti-fouling paint applied to the hulls of ocean going vessels. In 1988, Congress enacted a partial ban on TBT antifouling paints, which banned the application of antifouling paint containing organotin to vessels less than 25 meters in length. In 2008, organotin compounds were banned in anti-fouling paint by the International Convention on the Control of Harmful Anti-fouling Systems on Ships of the International Maritime Organization. It states that ships cannot bear organotin compounds on their hulls or external parts or surfaces, unless there is a coating that forms a barrier so that organotin compounds cannot leach out to reduce exposure by allowing recovery to occur.

The extent to which TBT is accumulated by saltwater animals from the field or from laboratory tests lasting 28 days or more has been investigated with four species of bivalve molluscs and two species of snails. Thain and Waldock, 1985 reported a BCF of 6,833 for the soft parts of blue mussel spat exposed to 0.24 µg/L for 45 days. In other laboratory exposures of blue mussels, Salazar et al.,1987 observed BCFs of 10,400 to 37,500 after 56 days of exposure. BAFs from field deployments of mussels were similar to the BCFs from laboratory studies: 11,000 to 25,000 in Salazar and Salazar 1990a and from 5,000 to 60,000 in Salazar and Salazar 1991. In a study by Bryan et al., 1987a, laboratory BCFs for the snail *Nucella lapillus* (11,000 to 38,000) also were similar to field BAFs (17,000). Year-long laboratory studies by Bailey et al.,1991 and Harding et al., 1996 produced similar BAFs in *N. lapillus ranging* from 6,172 to 21,964.

Whales. TBTs are found in cetacean and pinnipeds globally and are generally are more concentrated in liver tissue than other organs. Butyltins were generally higher in coastal species than pelagic species. Kim et al., 1998 found that hepatic cells exposed in vitro to 290 ug/l TBT had reduction in cytochrome p450 expression. Nakata et al., 2002 found reductions in lymphocyte production at TBT concentrations of 89 ug/l in Dall Porpoise, Bottlenosed Porpoise and Sea Lion.

Sharks. Dwivei and Trombetta (2006) found that stingrays exposed to tributyltin-oxide for 3 hours exhibited swollen gill epithelia at concentrations as low as 5 ug/l.

Sea Turtle. There is no information in the Ecotox database on TBT in turtles. Our literature search found one paper on TBT in turtles. TBT was not detected in turtle eggs of *Natator depressus* in Australia (Ikonomopoulou et al., 2011).

Clams. Inoue et al., 2006 found reduced embryo development in fertilized eggs of the Manila clam (*Ruditapes philippinarum*) exposed to 0.062 ug/l TBT for 23 hours. Maternal clams exposed to 0.061 ug/l TBT for 3 weeks exhibited reduced embryo development.

Mortality studies showed that the LC_{50} of the clam *Anadara rhombea* for 96 h exposure was 370 ug/l for tributyltin-chloride (Ranalalitha et al., 2014). At a concentration of 37 ug/l phosphatase activity was initiated in the digestive glands of *A. rhombea*.

Corals. Negri and Heyward, 2001, showed that fertilization of the coral *Acropora millepora* was inhibited by TBT at 200 ug/l *(IC_{50})* and larval metamorphosis was inhibited at 2 ug/l (IC_{50}). Watanabe et al., 2006 demonstrated significant mortality in *Acropora millepora* after exposure to 5 µg/l of TBT, and partial tissue detachment at 1 µg/l. There was no significant decrease at 0.2 ug/l even after 10 days of exposure. Watanabe et al., 2006 noticed a significant decrease in the symbiont population at 1 ug/l. Bao et al., 2011 showed toxicity of TBT to the larvae of *Acropora tumida* (LC_{50} = 7.5 ug/l; LC_{10} = 0.67 ug/l).

Summary. EPA's approval of the CNMI's tributyltin water quality standard is not likely to affect whales and sharks as they are mostly pelagic organisms and not likely to spend significant time in the near shore environment. EPAs' research has not found any thresholds for the listed species or their surrogates in the Ecotox database or in the scientific literature that are less than either the acute (0.0074 ug/l) or chronic (0.42 ug/l) tributyltin standards. EPA finds that the tributyltin standards are not likely to adversely affect any of the threatened or endangered species identified by NMFS.

VI. Critical Habitat

None

VII. Magnuson-Stevens Fishery Conservation and Management Act – Essential Fish Habitat.

None

VIII. References

Bao V.W.W., Kenneth M.Y. Leung, Jian-Wen Qiu, Michael H.W. Lam. 2011. Acute toxicities of five commonly used antifouling booster biocides to selected subtropical and cosmopolitan marine species. Marine Pollution Bulletin 62 (2011) 1147–1151

Barrera-García, A., O'Hara, T., Galván-Magaña, F., Méndez-Rodríguez, L.C., Castellini,J.M., Zenteno-Savín, T., 2013. Trace elements and oxidative stress indicators inthe liver and kidney of the blue shark (*Prionace glauca*). Comp. Biochem. Physiol.A 165, 483–490.

Burger J. 2008. Assessment and management of risk to wildlife from cadmium. Science of the Total Environment. 38:37-45.

Caurant, P., P. Bustamante, M Boardes and P. Miramand. 1999. Bioaccumulation of cadmium, copper and zinc in some tissues of three species of marine turtles stranded along the French Atlantic coasts. Marine Pollution Bulletin 38(12)1085-1091.

Cheng, Y., Z. J. Shan, J. Y. Zhou, Y. Q. Bu, P. F. Li, and S. Lu. 2017. Effects of 4-nonylphenol in drinking water on the reproductive capacity of Japanese quails (*Coturnix japonica*). Chemosphere 175:219-227.

Choi J Y, J Yu, D B Yang, K Ra, K T Kim, G H Hong and K H Shin. 2011. Acetylthiocholine (ATC) - Cleaving cholinesterase (ChE) activity as a potential biomarker of pesticide exposure in the Manila clam, *Ruditapes philippinarum,* of Korea. Marine Environmental Research 71:162-168

Cortes-Gomez A A, Diego Romero, Marc Girondot. 2017 The current situation of inorganic elements in marine turtles: A general review and meta-analysis. Environmental Pollution 229:567-585

Crane, M, M Finnegan, L Weltje, S Kosmala-Grzechnik, M Gross and J R. Wheeler e 2016Acute oral toxicity of chemicals in terrestrial life stages of amphibians: Comparisons to birds and mammals. Regulatory Toxicology and Pharmacology 80:335-341

Denton, B.G. Bearden, Lucrina, P. Concepcion, H.R. Wood, R.J. Morrison. 2006. Contaminant assessment of surface sediments from Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. G.R.W. Marine Pollution Bulletin 52: 696–718.

Duquesne S J and J.C. Coil. 1995. Metal accumulation in the clam Tridacna crocea under natural and experimental conditions Aquatic Toxicology 32 (1995) 239-253.

Endo, T, Hisamichi, Y., Haraguchi, K., Kato, Y., Ohta, C., Koga, N., 2008. Hg, Zn and Culevels in the muscle and liver of tiger sharks (*Galeocerdo cuvier*) from the coast of Ishigaki Island, Japan: relationship between metal concentrations and body length. Mar. Pollut. Bull. 56, 1774–1780.

Ento T, O. Kimura, H. Ogasawar, C. Ohta, N. Koga, Y. Kato and K. Haraguchie. 2015. School Mercury, cadmium, zinc and copper concentrations and stable isotope ratios of carbon and nitrogen in tiger sharks (*Galeocerdo cuvier*) culled off Ishigaki Island, Japan. Ecological Indicators 55:86-93. dx.doi.org/10.1016/j.ecolind.2015.03.008

Fryday S, Jarratt N and Stein J, 2014. Scientific services to support EFSA systematic reviews: Lot 5 Extensive literature search and reviews as preparatory work for the update of the Guidance of EFSA on the Risk Assessment for Birds and Mammals with regards to dermal and inhalation exposure. EFSA supporting publication 2014:EN-637, 337 pp.

Goodman, L. R., Hansen, D. J., Coppage, D. L., Moore, J. C., & Matthews, E. 1979. Diazinon: Chronic toxicity to, and brain acetylcholinesterase inhibition in, the sheepshead minnow, Cyprinodon variegatus. Trans. Am. Fish. Soc, 108, 479-488.

Guerranti C, M. Baini, S Casini, S. E. Focardi, M. Giannetti, C. Mancusi, L. Marsili, G.Perra, M. Fossi.2014. Pilot study on levels of chemical contaminants and porphyrins in *Caretta caretta* from the Mediterranean Sea. Marine Environmental Research 100:33-37. http://dx.doi.org/10.1016/j.marenvres.2014.01.004

Guirlet E. and K. Das 2011. Acute toxicities of five commonly used antifouling booster biocides to selected subtropical and cosmopolitan marine species. Heavy metal residues in tissues of marine turtles. Mar. Pollut. Bull. 46, 397-400.

Hecht S A, J S Gunnarson, B L Boese, J O Lamberson, C Schaffner, W Giger and P C Jepson. 2004. Influences of sedimentary organic matter quality on the bioaccumulation of 4-nonylphenol by estuarine amphipods. Environ. Toxicol. Chem 23:865-873

Hedayati A and R Tarkhani 2014. Hematological and gill histopathological changes in iridescent shark, *Pangasius hypophthalmus* (Sauvage,1878) exposed to sublethal diazinon and deltamethrin Concentrations. Fish Physiol Biochem 40:715–720

Ikonomopoulou, M.P., Olszowy, H., Limpus, C., Francis, R., Whittier, J., 2011. Trace element concentrations in nesting flatback turtles (*Natator depressus*) from Curtis Island, Queensland, Australia. Mar. Environ. Res. 71: 10-16.

Inoue S. Y. Oshima, H. Usuki, M. Hamaguchi, Y. Hanamura, N. Kai, Y. Shimasaki and T. Honjo. 2006. Effects of tributyltin maternal and/or waterborne exposure on the embryonic development of the Manila clam, *Ruditapes philippinarum* Chemosphere 63:881–888

Kawahata H., H. Ohta, M. Inoue and A. Suzuki. 2004. Endocrine disrupter nonylphenol and bisphenol A contamination in Okinawa and Ishigaki Islands, Japan—within coral reefs and adjacent river mouths. Chemosphere 55:1519-1527

Klumpp D W and J. S. Lucas. 1994. Nutritional ecology of the giant clams *Tridacna tevoroa* and *T. derasa* from Tonga: influence of light on filter-feeding and photosynthesis Marine Ecology Progress Series 107: 147-156

Kung T, Lee S, Yang T and W. Wang. 2018. Survey of selected personal care products in surfacewater of coral reefs in Kenting National Park, Taiwan. Science of the Total Environment. 635:1302-1307. https://doi.org/10.1016/j.scitotenv.2018.04.115.

Martin-Skilton, R., R. Thibaut, and C. Porte. 2006. Endocrine alteration in juvenile cod and turbot exposed to dispersed crude oil and alkylphenols. Aquatic Toxicology **78**: S57-S64.

Mitchelmore C L, E. Alan Verde and V M. Weis, 2007. Uptake and partitioning of copper and cadmium in the coral *Pocillopora damicornis.* Aquatic Toxicology 85 (2007) 48–56

Nakata H, A. Sakakibara, M. Kanoh, S. Kudo, H. Watanabe, N. Nagai, N. Miyazaki, Y. Asano and S. Tanabe. 2002. Evaluation of mitogen-induced responses in marine mammal and human lymphocytes by in-vitro exposure of butyltins and non-ortho coplanar PCBs. Environmental Pollution 120:245–253

Nice H.E., M.C. Thorndyke, D. Morrit. S. Steele and M. Crane. 200. Development of *Crassostrea gigas* Larvae is affected by 4-nonylphenol. Marine Pollution Bulletin 40(6) 491-496.

Negri A.P and A.J. Heyward 2001. Inhibition of coral fertilisation and larval metamorphosis by tributyltin and copper Marine Environmental Research Volume 51(1):17-27

Pachura-Bouchet, S., C. Blaise, and P. Vasseur. 2006. Toxicity of nonylphenol on the cnidarian *Hydra attenuata* and environmental risk assessment. Environmental Toxicology **21**:388-394.

Pachura, S., J. P. Cambon, C. Blaise, and P. Vasseur. 2005. 4-Nonylphenol-induced toxicity and apoptosis in *Hydra attenuata*. Environmental Toxicology and Chemistry **24**:3085-3091.

Paez-Osúna, F., Calderon-Campuzano, M.F., Soto-Jimenez, M.F. and Ruelas-Inzunza, J.R., 2010. Trace metals (Cd, Cu, Ni, and Zn) in blood and eggs of the sea turtle *Lepidochelys olivacea* from a nesting colony of Oaxaca, Mexico. Archives Environ. Contam. Toxicol. 59, 632e641.

Santos N., F., A. Silva Martins, D. R. Faust, H. Sakai, A. Bianchini, C. Carneiro da Silva, and A. A Aguirre. 2018. Cadmium in tissues of green turtles (*Chelonia mydas*): A global perspective for marine biota. Science of the Total Environ. 637–638 (2018) 389–397

Ranilalitha1, M. Sukumaran1 and S. Raveendran. 2014. Effect of TBTCL on phosphatases activity in estuarine edible clam *Andara Rhombea* Born (Bivalvia, Mollusca). International Journal of Pure and Applied Zoology. Volume 2, Issue 4, pp: 315-320, 2014

Reichelt-Brushett A.J. and P. L. Harrison. 2005. The effect of selected trace metals on the fertilization success. Coral Reefs (2005) 24: 524–534. DOI 10.1007/s00338-005-0013-5
Knop, Daniel. Giant clams a comprehensive guide to the identification and care of Tridacnid clams. Ettlingen: Dähne Verlag, 1996, ISBN 3-921684-23-4

Reichelt-Brushett A.J. and P. L. Harrison. 1999. The Effect of Copper, Zinc and Cadmium on Fertilization Success of Gametes from Scleractinian Reef CoralsP. Marine Pollution Bulletin Volume 38(3):182-187.

Ricciardi F. V. Matozzo and M. Gabriella Marin. 2008. Effects of 4-nonylphenol exposure in mussels (*Mytilus galloprovincialis*) and crabs (*Carcinus aestuarii*) with particular emphasis on vitellogenin induction. Marine Pollution Bulletin 57 (2008):365–372

Sakai, H., K. Saeki, H. Ichihashi, H. Suganuma, S. Tanabe and R. Tatsukawa. 2000. Species-Specific Distribution of Heavy Metals in Tissues and Organs of Loggerhead Turtle (*Caretta caretta*) and Green Turtle (*Chelonia mydas*) from Japanese Coastal Waters. Marine Pollution Bulletin Vol. 40(8):701-709.

Shafir S., I. Halperin and B. Rinkevich. 2014. Toxicology of Household Detergents to Reef Corals. Water Air Soil Pollut (2014) 225:1890. DOI 10.1007/s11270-014-1890-4
Storelli, M.M., Marcotrigiano, G.O., 2003.

Shai, Z. 2018. Email Communication with Nicole Tachicki, US EPA Region 9 on August 21, 2018.

Storelli M.M. and G.O. Marcotrigiano. 2003. Heavy metal residues in tissues of marine turtles. Marine Pollution Bulletin 46:397–400

Turoczy, N.J., Laurenson, L.J.B., Allinson, G., Nishikawa, M., Lambert, D.F., Smith, C.,Cottier, J.P.E., Irvine and S.B., Stagnitti, F., 2000. Observations on metal concentrations in three species of shark (*Deania calcea*, *Centroscymnus crepidater*, and *Centroscymnus owstoni*) from Southeastern Australian Waters. J. Agric. FoodChem. 48, 4357–4364.

U.S. EPA. 2010. Registration review – preliminary problem formulation for ecological risk and environmental fate, endangered species, and drinking water assessments for carbaryl. September 3, 2010. EPA-HQ-OPP-2010-0230-0004.

Vas, P., 1991. Trace metal levels in sharks from British and Atlantic waters. Mar.Pollut. Bull. 22, 67–72.

Verderame, M., and E. Limatola. 2015. Interferences of an environmental pollutant with estrogen-like action in the male reproductive system of the terrestrial vertebrate *Podarcis sicula*. General and Comparative Endocrinology **213**:42993.

Verderame, M., M. Prisco, P. Andreuccetti, F. Aniello, and E. Limatola. 2011. Experimentally nonylphenol-polluted diet induces the expression of silent genes VTG and ER alpha in the liver of male lizard *Podarcis sicula*. Environmental Pollution **159**:1101-1107.

Wang R, Wang X, Wu L and M Mateescu. 1999. Toxic effects of cadmium on the isolated heart of dogfish shark, *Squalus Acanthias*. Journal of Toxicology and Environmental Health Part A, 57(7):507-519, DOI: 10.1080/009841099157575

Ward, T., and R. Boeri. 1990a. Acute Flow Through Toxicity of Nonylphenol to the Sheepshead Minnow, *Cyprinodon variegatus*. Final Rep., Chemical Manufacturers Assoc., Washington, DC.

Watanabe T., I. Yuyama and S.Yasumura. 2006. Toxicological effects of biocides on symbiotic and aposymbiotic juveniles of the hermatypic coral *Acropora tenuis*. Journal of Experimental Marine Biology and Ecology. 339(2):177-188

Watts M. 2016. Highly hazardous toxic pesticides in the Pacific Islands. 2016. Pesticides Action Network